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RFIDS: From Invention to Innovation

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ABSTRACT

Radio-frequency identification (RFID) technology was invented nearly 60 years ago during the 2nd World War. However it has only been relatively recently that RFID technology adoption has been headlined in the popular press. With strategic business drivers such as supply chain management and e-commerce initiatives, and the need for increased value from improvements in product tracking, together with a push from consumers and regulatory demands for safe product handling, attention has focused on the adoption of RFID technology. This paper reviews the available literature on RFID technology and develops a four-phase RFID innovation diffusion adoption model which builds on Rogers (1995) innovation adoption literature. The paper will conclude with managerial implications and future directions for RFID research.

Key words: RFID, business processes, Wal-Mart, EPC, active tags, passive tags, RFID innovation diffusion model

INTRODUCTION

RFID technology is not a new innovation. One well-documented use of radio frequency technology dates back to World War II, when the British attached RFID transponders to their own aircraft to enable their radar system to differentiate between their own planes and incoming German aircraft (O'Connor, 2005). Throughout the ensuing years, there have been many notable uses of RFID technology in the commercial arena. One museum in Rotterdam uses RFID to guard its priceless paintings. In addition, scores of livestock have been tagged with RFID in order to track them in the event of a disease outbreak. One of the most visible uses of RFID in today's society is automated toll-collection on turnpikes and bridges, where cars display an RFID tag in their window and tollbooths equipped with readers identify the car and then charge the toll to the correct account as the car passes through the booth (EPCglobal, 2004).

In the US specifically, consumer and regulatory demands as well as security measures for safe product handling have increased pressure on companies to improve the accuracy of product tracking. Standards organizations such as EPCglobal (formerly known as the Auto ID Centre) have advanced the progress of standards, generating increased interest in RFIDs (Jabjiniak & Gilbert, 2004). On the technology front, advances such as declining chip and reader prices and the increased ability to inexpensively and efficiently send data have provided the impetus for some large scale companies to begin piloting RFID applications.

Major organizations such as Wal-Mart are currently investing heavily in RFID tags to aid in trimming supply-chain management expenses, reduce inventories, prevent theft, and avoid misdirection of shipments. In a major strategy that could ripple across multiple industries, Wal-Mart announced in June of 2003 that it would require its top 100 suppliers to equip incoming crates and palettes with RFID chips by January 2005 to link into Wal-Mart's RFID infrastructure. It has been estimated that Wal-Mart's announcement will cost its suppliers $2 billion. This includes not only the cost of tags and readers, estimated at $5 to $10 million per manufacturer, but also system integration, changes to current supply chain applications, and storage system upgrades, which may amount to $13 million per manufacturer (RFID Journal, 2003). In support of this new policy, Wal-Mart insists that RFID tags can be acquired in bulk for 10 cents per tag, demonstrating strong support for the technology. In addition to Wal-Mart's pilot scheme, RFID has been tested in projects by other large scale organizations ranging from Tesco to Boeing and Airbus. In addition, the US Department of Defense is setting dates for RFID compliance and requiring top suppliers to conform. (Jabjiniak et al, 2004). Additionally, solution providers such as Deloitte, Accenture and IBM are investing in RFID specific hardware and software solutions and finding innovative ways to effectively use RFID technology in a variety of business settings.

In the USA and the European Union many companies in the food service supply chain, especially small and midsize enterprises, will be required to change their business processes to meet new safety and traceability requirements. The US Food and Drug Administrations proposed rules for complying with the Bioterrorism Act of 2002 requires lot codes or other similar identification for food products. The EU Food Safety Law 178/2002, scheduled to take effect in Europe in 2005, requires distribution and detailed records including to whom products were sold or distributed (Albrecht, 2004). These regulations will require businesses to produce and manage more information than ever before. Doing so in a timely and cost effective manner practically requires the use of some form of automated data collection (Abrahamson, 1991).

Despite the high costs, the market for RFID systems worldwide reached $965 million in 2002, while RFID hardware sales attained nearly $89 million in 2002 (Hickey 2003).

What is RFID?

RFID is a technology that uses a semiconductor (Micro computer chips smaller than a grain of sand) in a tag or label to store data. The tag can be affixed to physical objects to track items at a distance. Each chip is connected to an antenna that picks up electromagnetic energy beamed at it from a reader device. Data is transmitted from, or written to the tag or label when it is exposed to radio waves of the correct frequency and with the correct communications protocols. When it picks up the energy, the chip sends back its unique identification number to the reader device, allowing the item to be remotely identified anywhere from a couple of inches to up to 20 or 30 feet away (Albrecht, 2004).
As the microchip is connected to an antenna, a few centimetres square in total, it can send information when requested by a reader. By means of anticollision techniques, many tags can be read practically simultaneously, representing an enormous timesaving over barcode reading, which requires operators to find the right position for the reading of each barcode individually. Although RFID tags can work just like a "barcode". It can hold a unique article number which works like a "licence plate", calling the information relating to that number from a separate database. In the most commonly touted applications of RFID, the microchip contains an Electronic Product Code (EPC) with sufficient capacity to provide unique identifiers for all items produced worldwide (Chatterjee et al, 2003). But because it can contain a relatively large amount of digital data, the RFID tag can hold source information itself, as opposed to a mere "look-up" number, thus making it infinitely more useful for supply chain and many other applications. A further advantage is that RFID "readers" in a read-write system are also "writers"; meaning information can be written to tags at any point along the supply chain, and include a security and access procedure or a maintenance operation, using a hand-held wand or fixed reader (Hopper, 2005). With a barcode system the only way of changing information is to print a new barcode or alter information in the system's database. Additionally as opposed to barcodes, tags are reusable and have very long lives. Therefore in supply chain operations for example, containers are continually reused. In this instance there would be no need to relabel the containers, saving on manpower and other costs associated with label production and fixing (BearingPoint, 2003).

There are a variety of different types of tags that can be used: Active and passive tags are the most common and have different frequency and read range.

Active (self-powered) tags must have a battery source, they have a long read range (often 200-300 feet), large memories and are higher frequency than passive tags (readers need a strong signal to work well in a warehouse or manufacturing floor); tags typically cost US$25 to US$30 and include a battery with an estimated three to five year life span. It seems the general rule is the longer the range of the RFID the more expensive the tag (BearingPoint, 2003).

Passive (battery-less) RFID tags, are powered by radio frequency field of the nearby RFID reader and can therefore last indefinitely. Proximity tags reading range are within a 1-2 foot range; while long-range passive tags are within a 10-30 foot range. Typically, the data is sent to a distributed computing system involved in, perhaps, supply chain management or inventory control. As passive tags are much cheaper to manufacture and do not depend on a battery, the vast majority of RFID tags in existence are of the passive variety. Currently passive tags cost upward of US$0.40

The aim is to produce tags for less than US$0.05 to make widespread RFID tagging commercially viable. Analysts from independent research companies like Gartner and Forrester Research agree that a price level of less than $0.10 is only achievable in 6-8 years, a potential hurdle to widespread passive RFID adoption. As well the passive Class 1 RFID tags and their readers are still experiencing difficulty achieving 100 percent read success in noisy warehouses loaded with signal-distorting metal objects; and with their relatively weak signals, Class 1 tags do not propagate well through liquid (Chatterjee et al, 2003; Infochip systems, 2005) ,

RFID chips also come in different frequencies with Low frequency (125 kHz) chips working well in or around metal environments (see Table 1 Page 4) This variety of chip is extremely resistant to shock and vibration, high voltage, stray microwaves and x-rays, and temperatures up to 325°F (Infochip systems, 2005).

It is envisaged that RFIDs can solve many of the problems associated with bar codes. For example radio waves travel through most non-metallic materials, and can be embedded in packaging or encased in protective plastic for weather-proofing and greater durability. Additionally, Information from an RFID system – "the data capture" element is passed to management information systems. This data can then be used for such purposes as controlling stock levels, providing details for tracking products and even report temperatures on an item (Finkenzeller, 2003).

Frequency	Band characteristics	Typical applications
Low	125-135 kHz Short read range	Inexpensive low reading speed Access control Animal identification Inventory control Car immobilizer Manufacturing
Intermediate	10-15 MHz Short to medium read range	potentially inexpensive medium reading speed Access control Smart cards
High (UHF)	850-950 MHz 2.4-5.8 GHz Long read range	High reading speed Line of sight required Expensive Railroad car monitoring Toll collection systems

Table 1: Frequency Band Characteristics.

Is it just a better barcode?

RFID tags are often envisioned as a replacement for UPC or EAN bar-codes, having a number of important advantages over the older bar-code technology. However it is unlikely that RFID tags will replace barcodes. It is much more likely that RFIDs will be used as a complementary technology. This is for two main reasons: 1) Cost of tags, 2) necessity to individually recognise an individual item. The cost of a tag is still relatively high, this is expected to reduce in time due to economies of scale (Sheffi, 2004). However, it is unlikely that lower value items will justify any costs associated with tagging. Further the storage of data associated with tracking goods down to item level will run into many terabytes leading to storage, management and data interrogation issues. It is much more likely that goods will be tracked at pallet level using RFID tags, and at item level with product unique rather than item unique barcodes (Van Dulken, 2004).

The main difference between RFIDs and bar codes is that bar codes are line-of-sight technology (see Table 2 Page 5). That is, a scanner is required to "see" the bar code to read it. Radio frequency identification, by contrast, does not require line of sight. RFID tags can be read as long as they are within range of a reader. Problems with bar codes are that if a label gets damaged during shipping and handling there is no way to scan the item (The Economist, 2003). Also standard bar codes identify only the manufacturer and product, not the unique item. The bar code on a loaf of bread is the same as every other loaf of bread, making it impossible to identify and track which loaf has passed its expiration date first (BearingPoint, 2003). Also RFID codes are long enough that every RFID tag may have a unique code, while current UPC codes are limited to a single code for all instances of a particular product

(Sheffi, 2004). The uniqueness of RFID tags means that a product may be individually tracked as it moves from location to location, finally ending up in the consumer's hands (Van Dulken, 2004). Thus providing companies with the ability to combat theft and other forms of product loss.

RFID Tags	*Bar Codes*
Electronic information can be over-written repeatedly.	Bar Code information cannot be updated
RFID tags can be read up updated without line of sight	Bar codes require line of sight
Multiple tags can be read simultaneously	Bar Codes can only be read individually
Smart labels are ultra thin, and can be read when concealed within a folder or item	Bar Codes must be visible to be logged
Tags can be hiddne to provide enhanced security	Bar Codes rquire line of sight
RIFD tags are able to cope with hrash and dirty environments	Bar Codes cannot be read if they become dirty or damaged
Tracking are automatic with RFID tags	Bar Codes require manual logging – human error becomes a factor

Table 2: Comparison between RFID Tags and Bar Codes.

As mentioned earlier, RFIDs should not be seen as a replacement for the barcode, it is a technology that can help reduce waste, curtail theft, manage inventory, streamline logistics and increase productivity. As such RFID applications are being used in a variety of settings for example: in healthcare (for monitoring patients), construction (for managing projects and equipment), in cement to monitor temperature, density and life expectancy and transportation (for monitoring baggage and passengers in airports).

CHALLENGES TO RFID ADOPTION

There is a substantial amount of media hype with regards RFID adoption in the popular press. The following statements were obtained from the same magazine (Computerweekly, 2005):

> "Radio frequency identification can transform supply chain management, reduce errors and cut fraud"
> "There will be a surge in RFID use during 2005, with billions of RFID tags being commissioned" according to the latest predictions from Deloitte Touche Tohmatsu
> "Lack of standards and high costs are the main barriers to RFID adoption in the short term"

Although, consulting firms such as Deloitte are urging businesses to consider using RFID technology beyond basic tracking applications, many businesses have taken a wait and see stance toward RFID adoption (Jabjiniak et al, 2004). CIO of CHEP International states that "Companies will not want to invest in a system if their tags can't be read by trucking companies, retailers and other businesses." "The problem is the entire supply chain hasn't bought into it yet," he argues. "If you're the first person with a mobile phone, it's useless. But as soon as everyone has one, it becomes valuable."(Roberti, 2003).

A study of more than 130 large scale retailers across North America and Europe, conducted by analyst firm Gartner found that 64% cited prohibitive costs of RFID tags as the biggest barrier, 50% said the unclear business case was preventing roll-outs and 34% identified lack of standards as a barrier (Computerweekly, 2005). Very similar results were obtained from a survey conducted by BearingPoint (2004): 351 senior IT executives, directors and managers identified the top three RFID business risks as lack of standards (48%), lack of clear business benefits or ROI (38%) and lack of industry wide adoption (38%); the top three RFID technology risks included high costs of tags and readers (43%), obsolescence as standards/applications evolve (38%) and inadequate read ranges (35%) (Jabjiniak et al, 2004).

Interestingly ethics and privacy issues were not mentioned. These issues have also affected the uptake of RFIDs in some organisations. RFID technology's cost and other benefits to suppliers are apparent throughout the manufacturing, distribution, and sales processes, right up to when a cashier rings up the RFID-tagged item at the ~~register. Beyond that point, if the RFID remains active, the benefits to consumers become more ambiguous, and the~~

potential downsides, particularly as they relate to privacy, become more ominous. Some issues that will ultimately need to be addressed include the fact that the purchaser of an item will not necessarily be aware of or able to remove the tag. An RFID reader can read the tag at a distance without the knowledge of the individual. If a purchaser pays for a tagged item with a credit card or loyalty card, then the store could tie the unique ID of that item to the identity of the purchaser (Bhattacharya, 2005). Although Standards-based RFID specifications include the ability to send a "kill" command to the tag, with current RFID-tag and system designs, consumers have no guarantee and no indication of whether the system has in fact sent the command; consumers might not even view a permanently killed tag as a desirable outcome.

RFIDs as a Business Innovation

Widespread RFID adoption has been stymied by a lack of education regarding the technology, uncertainty about standards, high costs of the RFID technology and the lack of compatible software solutions to provide support to back end processes. There seems to be four major challenges for organizations to the adoption of RFIDs; Firstly, finding value from RFID implementation costs; secondly, mastering the complexity of the RFID technology; thirdly, mastering integration of RFID technology with critical business processes (including data integration) in essence business process reengineering and fourthly, planning to scale (Deloitte, 2004).

Users' acceptance presents a complex set of challenges, especially for companies such as Deloitte, KPMG and IBM who are heavily promoting RFID technology and are involved in developing innovative ways for organizations to use the technology. In this context how technological innovations are adopted and why they are adopted at different rates pose interesting questions. In the innovation diffusion literature; innovation is defined as an "idea, practice or object perceived as new by a unit of adoption" (Rogers, 1995, p.11). Rogers (1995) argues that getting a new idea adopted, even when it has obvious advantages, is very difficult (p. 1).

Using Rogers' description, an innovation must be new to the adopter (the adopter can be an individual, a group, a business or an organization) and can take many forms. Studying how innovation occurs, Rogers (1995) argued that it consists of four stages: invention, diffusion (or communication) through the social system, time and consequences. The information flows through networks. The nature of networks and the roles opinion leaders play in them determine the likelihood that the innovation will be adopted (Baskerville & Pries-Heje, 2001). Opinion leaders exert influence on adopters' behavior via their personal contact, but additional intermediaries called change agents and gatekeepers are also included in the process of diffusion. Rogers' innovation theory provides the link to the perceived lack of uptake of RFIDs by organizations. To develop this further Rogers' innovation theory has been used to provide the base for an adapted four-phase diffusion of innovation adoption model.

RFID Diffusion of Innovation Adoption Model

To assess the perceived adoption of RFIDs, a four phase model has been adapted from Rogers diffusion of Innovation model and includes in essence Rogers' S-shaped adoption curve (see figure 1). Using Rogers (1995) explanation, the S-curve indicates that a successful innovation will go through an initial period of slow growth, a period of rapid adoption, and a gradual leveling off. According to Rogers (1995) the period of rapid expansion, for most successful innovations, occurs when social and technical factors combine to permit the innovation to experience dramatic growth.

Diffusion is included in this model as it reflects the conditions which increase or decrease the likelihood that a new idea, product, or practice will be adopted by members of a given culture: in this case organizations. Diffusion of innovation theory predicts that media as well as interpersonal contacts provide information and influence opinions and judgments.

Time relates to the speed with which an innovation is adopted by potential adopters. According to Rogers (1995), this concept refers to the rate of adoption within the diffusion process. Rogers argues that the rate of adoption is positively related to perceived relative advantage, compatibility, trialability, and observability, and is negatively related to perceived complexity of the innovation. This occurs at the innovation phase. We argue that the business value will be dependent on how well the adopting organization adapts to the new innovation, while the business impact will be tempered by the speed of adoption.

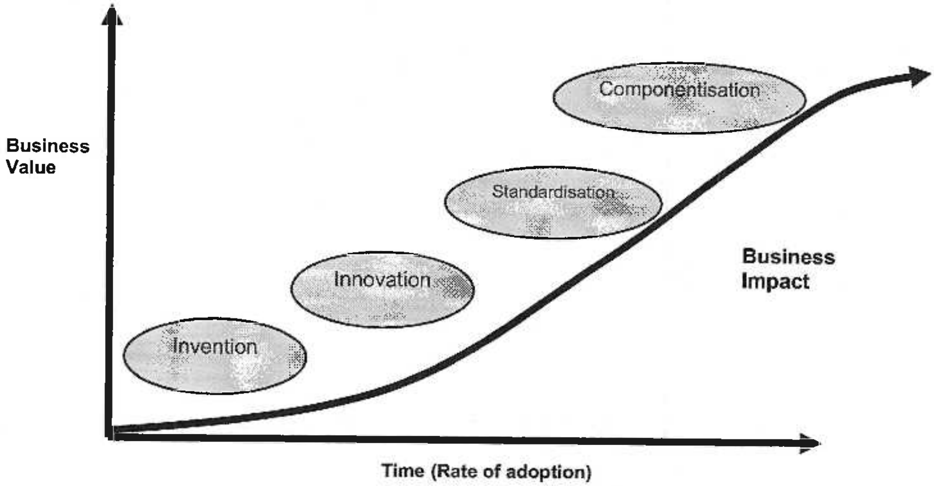

Figure 1: RFID Diffusion of Innovation Adoption Model.

Each phase of the RFID Diffusion Of Innovation Adoption Model will be discussed and examples provided to indicate how each phase supports the uptake of RFIDs:

Phase 1 – Invention. The invention is the prerequisite for the innovation to exist. RFIDs were invented nearly 60 years ago. During World War II, since the coast of occupied France was less than 25 miles away, the British, to distinguish between their own returning aircraft and those of the enemy, developed a system whereby a transponder was placed on Allied aircraft so that by giving the appropriate response to an interrogating signal, a "friendly" aircraft could automatically be distinguished from a "foe". This was the IFF or Identify: Friend or Foe system. This is the system upon which present day commercial and private aviation traffic control is still based. It was the first obvious use of Radio Frequency IDentification devices (O'Connor, 2005).

Phase 2 – Innovation. Rogers (1995) proposed five characteristics of innovation. These are: relative advantage, compatibility, complexity, trialability and observability and are discussed in detail below. Diffusion of the innovation is also included within this phase. Rogers (1995) states "diffusion is a particular type of communication in which the message content that is exchanged is concerned with a new idea" (p. 17). Thus, the diffusion process involves the spread of a new idea from its source to potential adopters.

1. Relative advantage - potential adopters need to see an advantage for adopting the innovation. Business drivers may include customer requirements; decrease in supply chain costs, reducing inventories, increasing a competitive advantage or in response to changing legal regulations.
2. Compatibility - innovations should fit with potential adopters' current practices and values. Although many organizations are currently using bar codes , the real value in RFIDs will not come from the replacement of bar codes where business processes were developed around the limitations of the bar code, but in the development of innovative business process opportunities. Therefore, the real value is where businesses build on the strengths of the RFID technology and reengineer business processes to capitalize on these strengths.
3. Complexity – the innovations' ease of use will lead to more rapid adoption. This is especially true of RFIDs. The specific business requirements and the ability of change agents (Deloitte, KPMG, IBM, EPCGlobal) to find innovative ways to use RFIDs in specific business setting will reflect time to adoption.
4. Trialability - potential adopters want the availability of "testing" before adopting. Many of the large scale organizations, such as Wal-Mart, US Department of Defense, Marks & Spencers, Boeing etc are trialing RFIDs with a view to full adoption.
5. Observability - potential adopters want to see observable results from an innovation. While trailing the RFID the organization is able to obtain first hand information on the use of the innovation and make an informed choice about its suitability and its ability to add business value.

Numerous cases of innovative uses of RFID tags abound. Two examples are cited: 1) Texas Instruments is working with the Vatican Library in Rome to RFID-tag, identify, and manage its extensive collection of nearly 2 million books, manuscripts, and other priceless items. 2) In January 2003, Michelin (a major tyre manufacturer) announced that it has begun testing RFID transponders embedded into tires. After a testing period that is expected to last 18 months, the manufacturer will offer RFID-enabled tires to car-makers. Their primary purpose is tire-tracking in compliance with the United States Transportation, Recall, Enhancement, Accountability and Documentation Act (TREAD Act).

These two examples have been developed over time, with substantial forethought into the adoption and use of the technology. In these two instances, RFIDs are used for internal recording, limiting the innovation to the extent that they are unable to interact with their stakeholders thus limiting their ability to add additional value at the present time. Therefore standards need to be developed that will provide compatibility and interoperability across the supply chain.

Phase 3 - Standardization. In this Phase standards are developed to facilitate widespread adoption of application development. As more people adopt the innovation to enable interoperability and diffusion of the innovation across the marketplace, it is argued that standards need to be developed before further applications can be created. Once the standards are stabilized and accepted, applications that started off as innovations, and which are now robust and built upon standards are componentized to enable on-selling to the market as a whole.

It is further argued that without standardization companies will be unable to use the innovation in business strategies to enable the supply chain or e-commerce. For example, Boeing is currently conducting RFID-tagged engine parts trials with Federal Express and Delta Airlines. The three companies' are currently using worldwide-standard, low frequency 13.56-MHz tags. EPCglobal is working on an international standard for the use of RFID and the Electronic Product Code (EPC) in the identification of any item in the suppply chain for companies in any industry, anywhere in the world. Some RFID systems use alternative standards based on the ISO-classification 18000-6 (Roberti, 2003). The EPCglobal gen 2 standard was approved in December 2004, and is likely to form the backbone of RFID tag standards.

Once these standards are fully developed and stabilized globally, there is likely to be an advent of off the shelf applications being developed (Finkenzeller, 2003).

Phase 4 – Componentization. This Phase reflects the ability of the innovation to be easily broken down into and rapidly built up from smaller components. In this context the application of the innovation such as prepackaged off the shelf software makes it readily available to industry. Thus providing economies of scale and lowering the price of items to consumers and increasing business value. Componentization gives innovators the opportunity to further develop their products and to on- sell it to other parties.

FUTURE DIRECTIONS

It appears that the major issues currently plaguing the RFID industry are price of the technology, standardization and adapting current processes to support the new technology.

For many companies the introduction of RFID technology has been associated with the replacement or enhancement of current technology supporting various business processes. The real strength of introducing this sort of technology will come about when existing processes have been extended or new processes are developed as a consequence of the RFID potential. The replacement of existing technology is a cheaper option and relatively low risk but with limited potential. The development of new business processes or the extension of existing ones will incur a higher cost with greater risk. While the opportunity for innovation and associated new business opportunities can justify these risks and costs, the potential is not in the technology but how it is applied in the various business settings. However the competitive advantage or potential to the company is far greater although there is a bigger up front cost. The potential gain is enormous in that it provides an innovation in new business directions and new business opportunities. The idea should be in developing new processes to provide innovation to the company that can be on sold to other organizations leading to commoditization. If companies want to replace existing technology then as RFID standards and commoditization occurs the costs and risks will decrease.

Although tag costs significant impact on the RFID value proposition and the outcome of the business case, major organizations will still develop this technology as they can absorb the costs to some extent and obtain economies of scale from the value chain right through to the retailer, as well as enjoying the business benefits that RFIDs can provide. These include reduction in losses of perishable items; reduced out of stock losses; better product management; reduction in the amount of inventory held, increase in inventory accuracy, reduce labor; increase data integrity and generate more meaningful and timely information through an RFID type infrastructure. Some of these benefits will not be readily apparent but will accrue over time.

Future research should be directed at validating the RFID Innovation Diffusion Adoption Model. This can be accomplished from research by focusing on the business drivers; analyzing the business benefits, the possible impediments and associated issues expected from the adoption of RFID technology in a variety of business settings.

CONCLUSION

Mark Easton (2004) from IBM Business Consulting services states that "RFID is probably the next big step in automated data capture for product flow right across the value chain" (p2). He goes further by indicating that RFID represents a significant business opportunity potential in supply chain management, customer relationship management and product loss management.

Many large companies, including Tesco, Wal-Mart, Gillette, and Proctor & Gamble, are experimenting with RFID tag technology. Tesco recently made the largest publicly announced single order of EPC RFID readers. Gillette and Procter & Gamble are two of WalMart's key partners and have invested in RFID in response to WalMart's requirements (Van Dulken, 2003). Gillette uses EPC RFID technology to uniquely identify cases and pallets of razors, shaving cream and toothpaste, while manufacturer Procter & Gamble use RFIDs to distinguish genuine from counterfeit products and to identify and recall outdated products. However, retailer support has been slow to gather, and it is estimated that RFID will not be economically feasible for a company's entire supply chain before 2006 (Fildes 2003). Wal-Mart is one of the few retailers that have required suppliers to include RFID in their products (Dow Jones, 2003).

Business consultants such as Deloitte, IBM and KPMG for example are providing the impetus for organizations to uptake the technology by developing innovative ideas. By acting as change agents they are exerting influence on adopters' behavior. The RFID diffusion of innovation adoption model has been developed to reflect the business adoption and builds on the characteristics of innovation as outlined by Rogers (1976). In this model the period of rapid expansion occurs when the social and technical factors combine. It is at this stage that the impact to the business will be greatest and the business will achieve value from the innovation. In this model time to adoption is a major factor, as is standardization.

If technology costs can be lowered and standards and privacy issues resolved, the major business advantages of using this technology should lead to widespread adoption in many organizations in the near future.

REFERENCES

Abrahamson, E. (1991). Managerial fads and fashions: the diffusion and rejection of innovations! *Academy of Management Review*, vol 16, pp 586-612.

Albrecht, K. (2004). Is there a tag in your bag? Caspian, Consumers Against Supermarket Privacy Invasion and Numbering located at http://www.boycotttesco.com/about.html

Baskerville R., & Pries-Heje, J. (2001). A multiple-theory analysis of a diffusion of information technology case. *Info Systems Journal,* Vol 11, pp 181–212.

BearingPoint (2003). Radio frequency identification (in retail): preparing for further globalization with RFID. Whitepaper

Bhattacharya, S. (2005). "Electronic tags for eggs, sperm and embryos" . Retrieved on 2 April 2005, located at http://www.newscientist.com/article.ns?id=dn7209

Chatterjee, R., Wolfe, P., Park, S., & Choi, J. (2003). Evaluation of using RFID passive tags for monitoring product location/owernship. Retrieved on 17 April 2005, located at www.ems-rfid.com

Margulius, D. L. (2005). The Rush to RFID. Computerworld.

Dow Jones Newswires. (2003). "Benetton to keep track of inventory with tiny transmitters," *Wall Street Journal*, March 12, 2003

Easton, M. (2004). RFID – A Business Perspective. IBM Business Consulting Services. Sapphire 2004. pp1-30

The EPCglobal Network™. (2004). Overview of Design, Benefits, & Security. Whitepaper, December, 2004. pp 1-13.

Fildes, N. (2003). "RFID could make toothpaste the next big thing," *Wall Street Journal*, March 14, 2003

Finkenzeller, K. (2003). "Fundamentals and Applications in Contactless Smart Cards and Identification" RFID-Handbook, (2nd edn). London: Wiley & Sons Ltd.

Hickey, K. (2003). "RFID grew in 2002," *trafficWorld*, May 5, 2003.

Infochip systems Inc. (2005). Managing Critical Equipment with RFID. Whitepaper, May 2005, pp 1-7.

Jabjiniak, B., & Gilbert, G. (2004). RFID Warrants a Strategic Approach. Business Integration Journal. Vol 12, 29-31.

O'Connor, M. C. (2005). Scotland Provides RFID Support. RFID Journal. January, 2005.

RFID Journal, "The cost of Wal-Mart's RFID edict," September 2003. Retrieved on 1 May 2005, located at http://www.rfidjournal.com

Roberti, M. (2003). Trends: RFID. eWeek CIO/Insight magazine. Retreived on 12 April located at http://www.cioinsight.com/print_article2/0,2533,a=25448,00.asp

Rogers, E.M. (1976). New Product Adoption and Diffusion. *Journal of Consumer Research, 2 (March),* 290 -301.

Rogers, E.M. (1995). *Diffusion of innovations (4th edition).* The Free Press. New York.

Sheffi, Y. (2004). RFID and the Innovation Cycle. *International Journal of Logistics Management* Vol 15, 1.

The Economist. (2003). "The best thing since the bar-code," Retrieved on 17 April 2005, located at www.economist.com/business/displayStory.cfm?story_id=1563928, February 6, 2003.

Van Dulken, S. (2004). RFID: The successor to bar codes? Contravision. Retrieved on 27 April 2005, Located at http://www.ideas21.co.uk/250